Inferring Mixing in the SPURS Region from Volumetric Salinity Budgets

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Objectives

- Use budgets formulated for different control volumes to isolate different processes
- Connect the salinity budgets in the SPURS region with the larger scale context of the basin- to global-scale general circulation
- Connect the synoptic time scale observations form SPURS with OGCM space and time scales

Alternative Control Volumes

Pointwise Mixed Layer (Tom Farrar yesterday)

$$h\frac{\partial\langle S\rangle}{\partial t} = -h\langle\vec{u}\rangle\bullet\nabla\langle S\rangle - \nabla\bullet\left\langle\hat{\vec{u}}\hat{S}\right\rangle - (\langle S\rangle - S_{-h})\left(\frac{\partial h}{\partial t} + \vec{u}_{-h}\bullet\nabla h + w_{-h}\right) + (E-P)S_r - \kappa\left.\frac{\partial S}{\partial z}\right|_{-h}$$

?

Eulerian Volume (Carton & Grodsky)

$$\frac{\partial[S]}{\partial t} = -[\nabla_h\bullet\vec{u}_h S] - w_{-h}S_{-h} + (E-P)S_r + \left[\kappa\frac{\partial S}{\partial z}\right]_{z=-h} + [F_h]$$

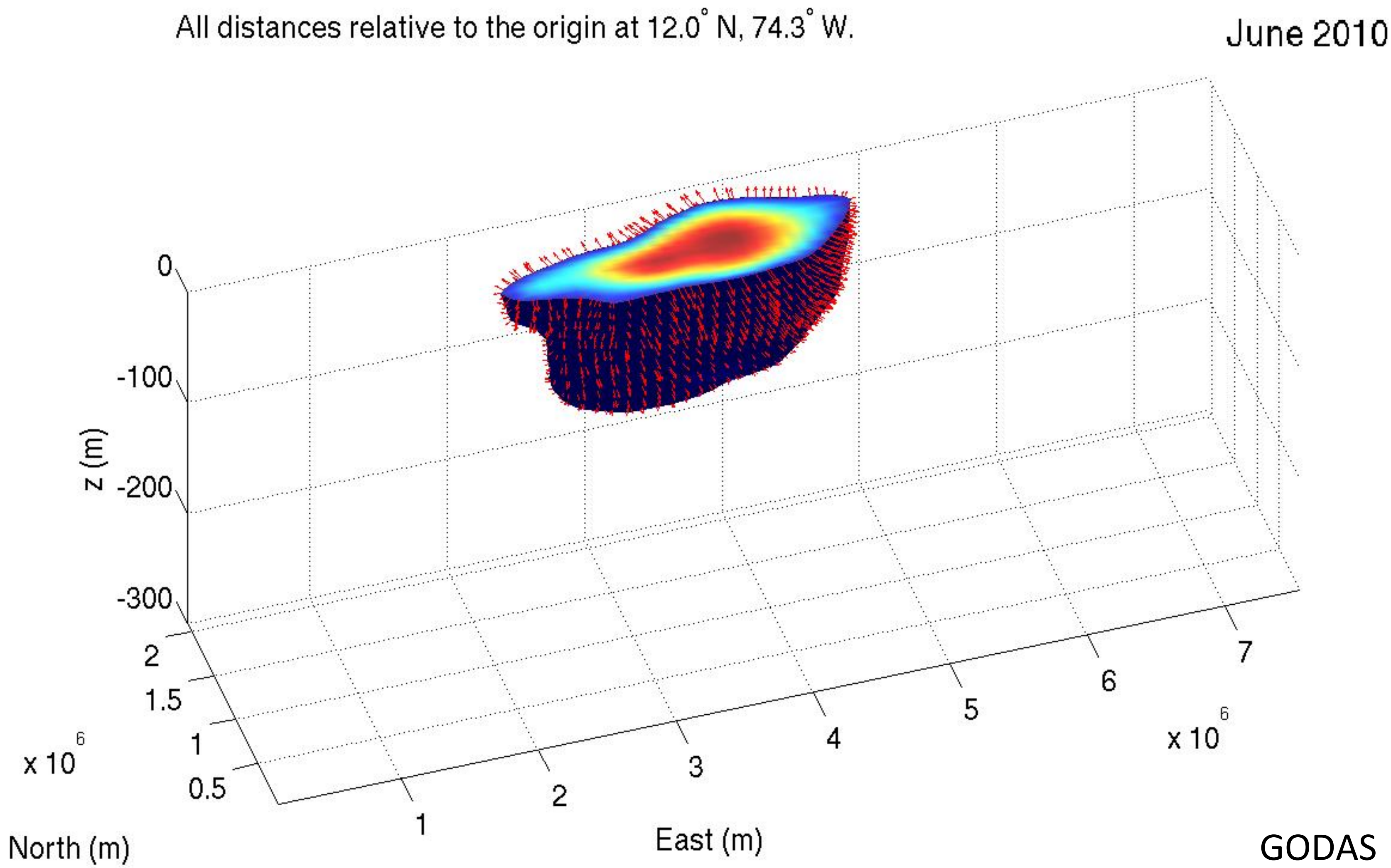
Isohaline Bounded Volume

$$V\frac{d\langle S\rangle}{dt} + (\langle S\rangle - S_c)\frac{dV}{dt} = \iint_S (E-P)S\,dA - \iint_B \vec{F}_{mix}\bullet\vec{n}\,dA$$

Models and Data Used

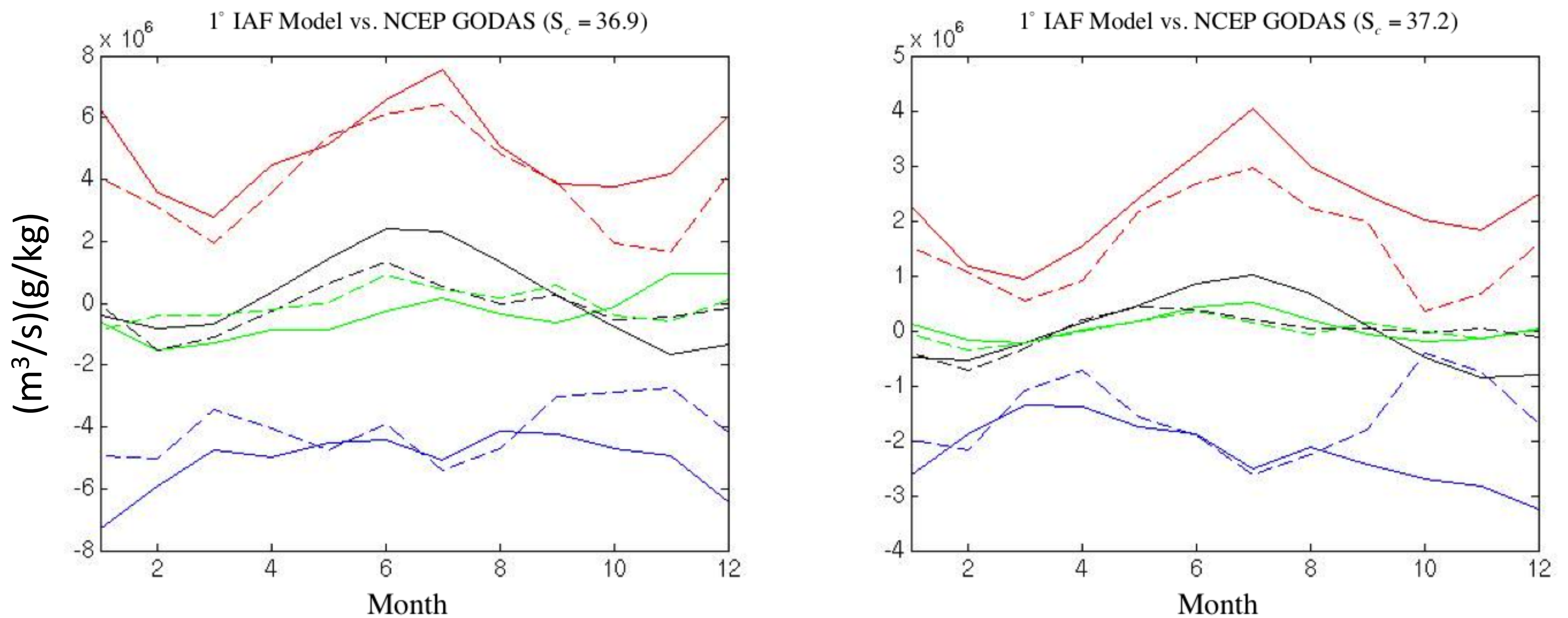
Model	Horizontal Resolution	Near Surface Vertical Resolution	Surface Forcing	Assimlation
CCSM-NY	0.3° to 0.6° x 1.125°	10m	CORE Normal Year	none
CCSM-IAF	0.3° to 0.6° x 1.125°	10m	CORE Interannual (1947-2009)	none
NCEP GODAS	1/3° to 1° x 1°	10m	NCEP Reanalysis-2 (1980-2012)	3DVar (Temp. profiles + synthetic salinity)

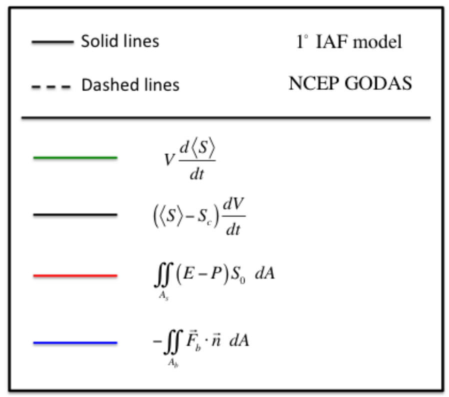
The North Atlantic "Salt Pool"



GODAS

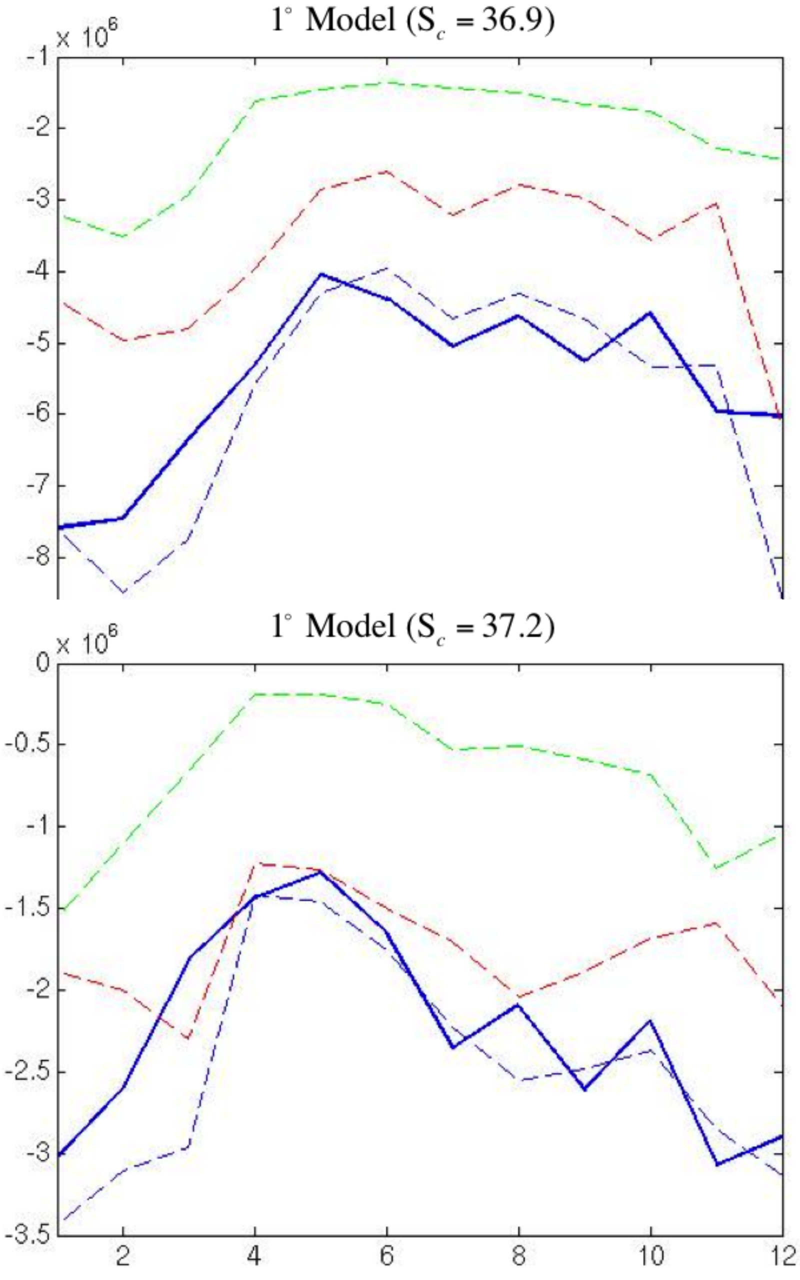
Isohaline Salt Budget for 2009





$$\underbrace{V\frac{d\langle S\rangle}{dt}+\left(\langle S\rangle-S_c\right)\frac{dV}{dt}=\iint_S (E-P)S\,dA}_{\text{Calculated}}-\underbrace{\iint_B \vec{F}_{mix}\bullet\vec{n}\,dA}_{\text{Residual}}$$

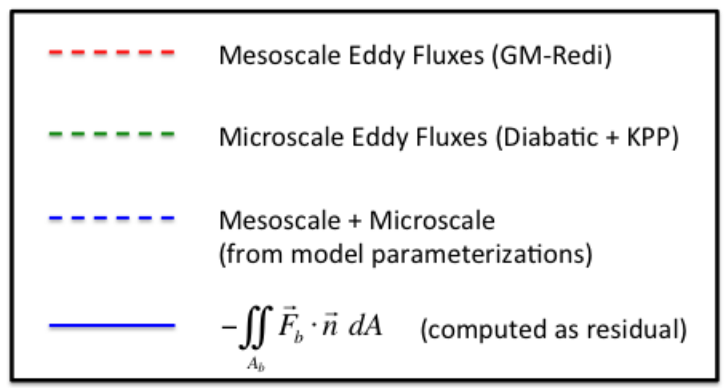
What Processes Account for the Mixing?



$$\vec{F}_{mix} = \underline{\underline{\mathrm{K}}}_{GM} \nabla S + \kappa(\gamma + \frac{\partial S}{\partial z})$$

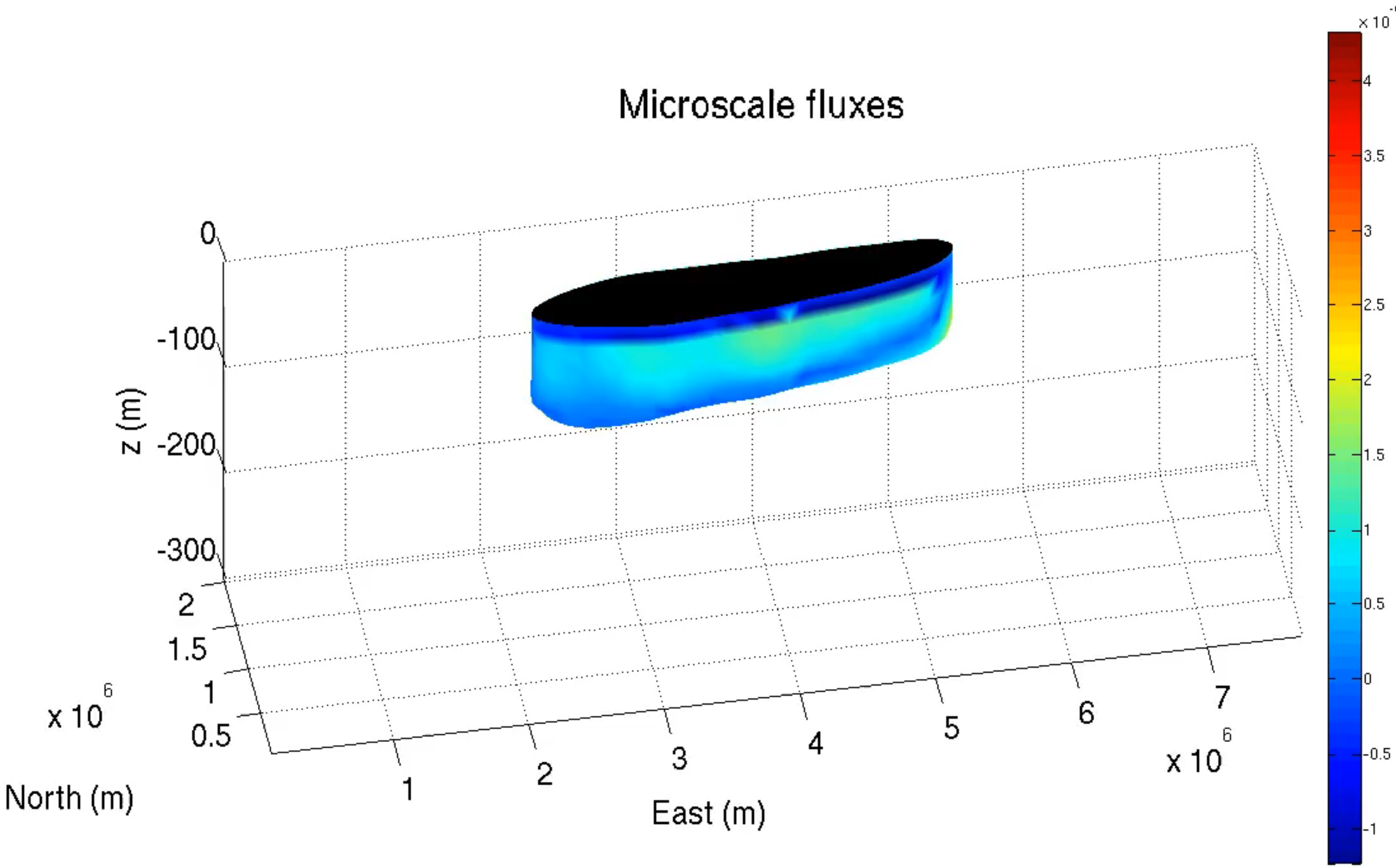
Mesoscale (GM)+
Submeso (FFM)

Microscale (KPP)

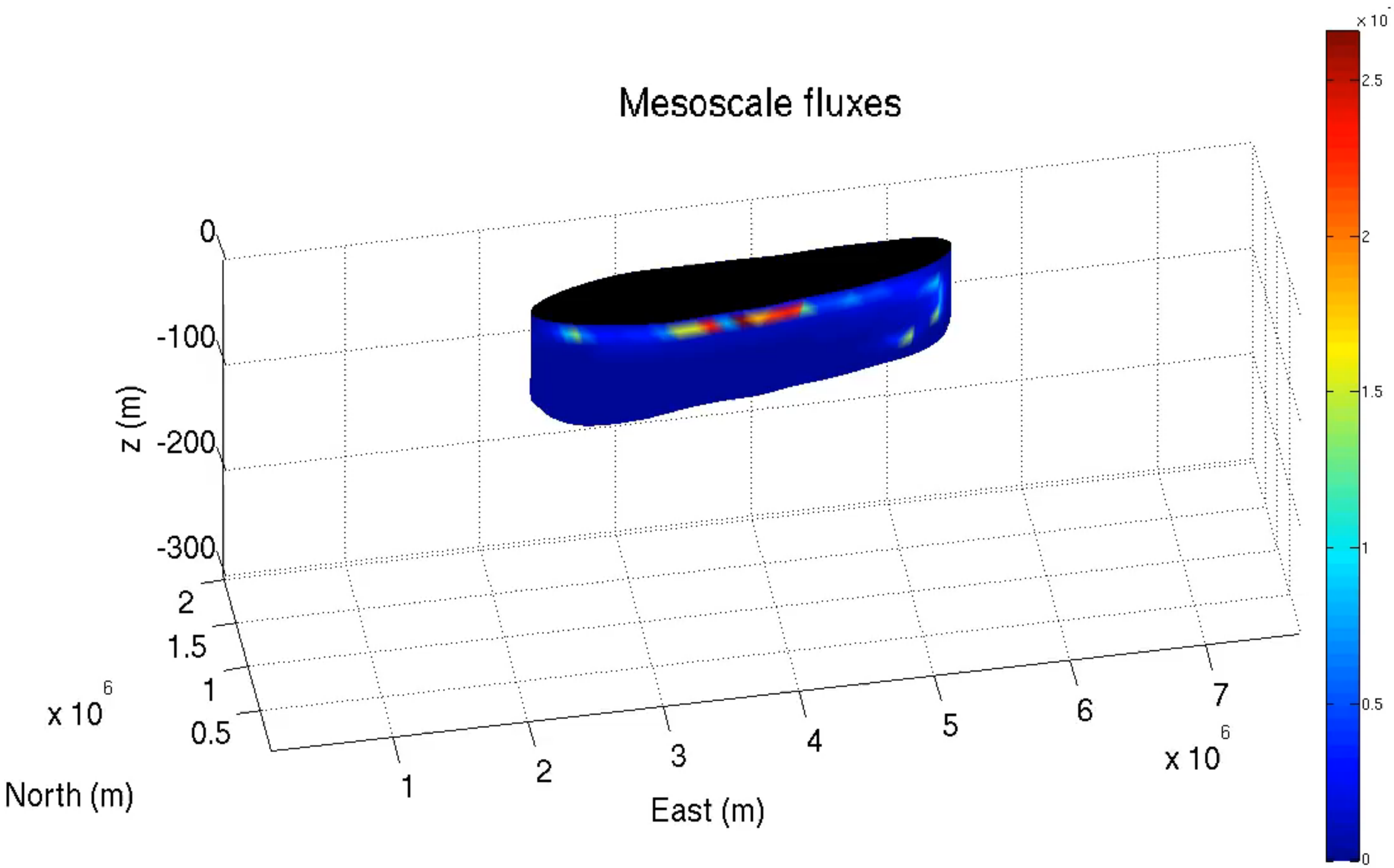


CCSM-NY

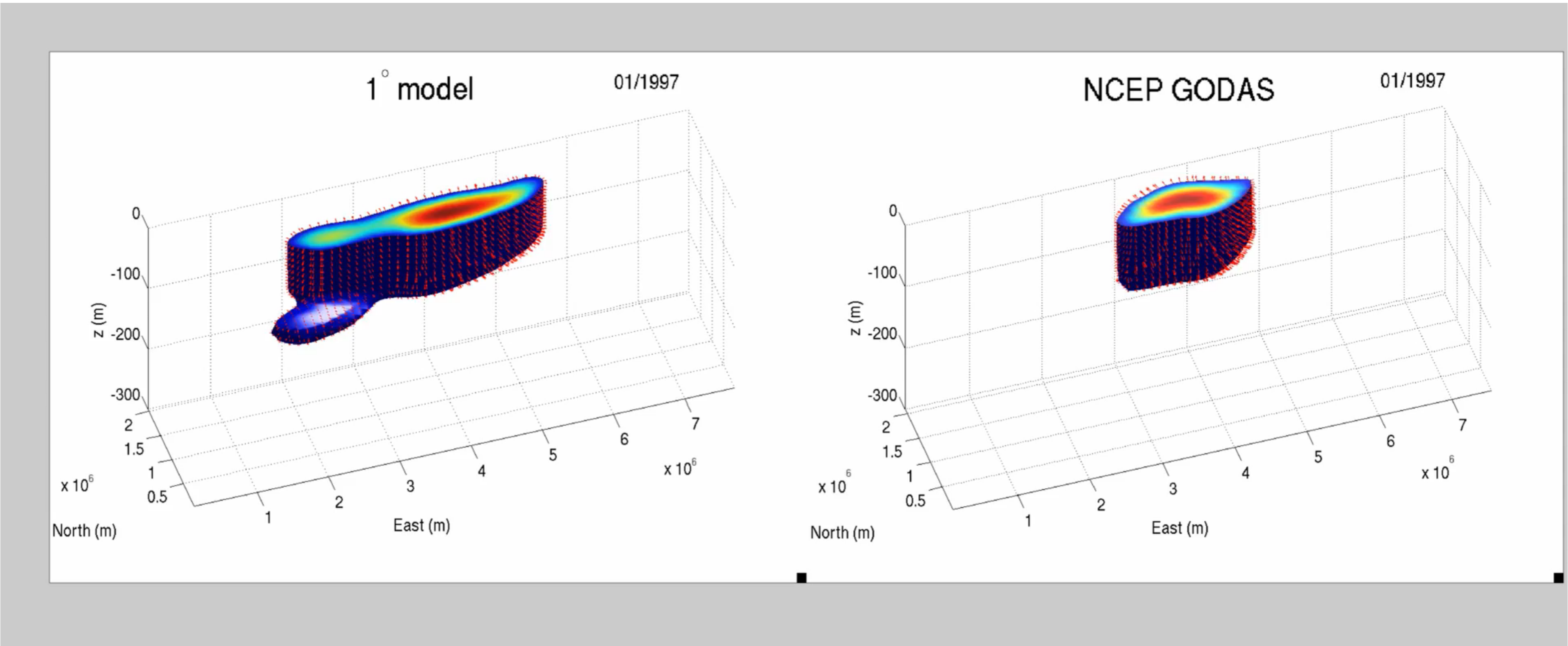
Distribution of Microscale Fluxes



Mesoscale Fluxes



Interannual Variability (S=37.2)



Summary

- The net turbulent flux through the salt pool isohaline surfaces can be estimated from surface data alone
- In contrast to the warm pool, both isopycnal and diapycnal turbulent fluxes contribute to the net flux through the salt pool.
- Considerable inter-annual variability in both the surface and subsurface signatures of the salt pool even without eddies.

Questions and Next Steps

- Examine eddy resolving solutions and SPURS state estimates in this framework.
  - What time and space scales of smoothing are required to define useful control volumes?
  - Are explicit and parameterized net mesoscale fluxes of similar importance?
  - Can we reconcile the different budgets into a coherent picture of mixing in this domain?
- Salinity variance budgets in isohaline volumes as additional diagnostic of mixing.